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Coral Banks Occurring in Deep Water on the Blake Plateau

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INTRODUCTION

Approximately 165 miles southeast of Charleston, South Carolina, is an extensive area of irregular topography situated near the northern end of the otherwise relatively flat Blake Plateau (fig. 1). This area comprises about 1200 to 1500 square miles and contains over 200 distinct features having topographic expression ranging from a few tens of feet to as much as 480 feet. S. T. Knott and J. B. Hersey of Woods Hole Oceanographic Institution first observed these banks by means of the echo sounder in the spring of 1956. These echo soundings aroused speculation as to the nature of these features and led to subsequent investigations with the use of additional methods. Certain of these features have now been sufficiently studied to be identified as coral banks. Other topographic highs in this area having a like morphology probably are also accumulations of coral skeletal debris. Together they constitute an extensive area of living deep-water coral.

Reef-like coral structures occurring at depth in the sea have been a matter of published record for nearly 100 years, the first description of

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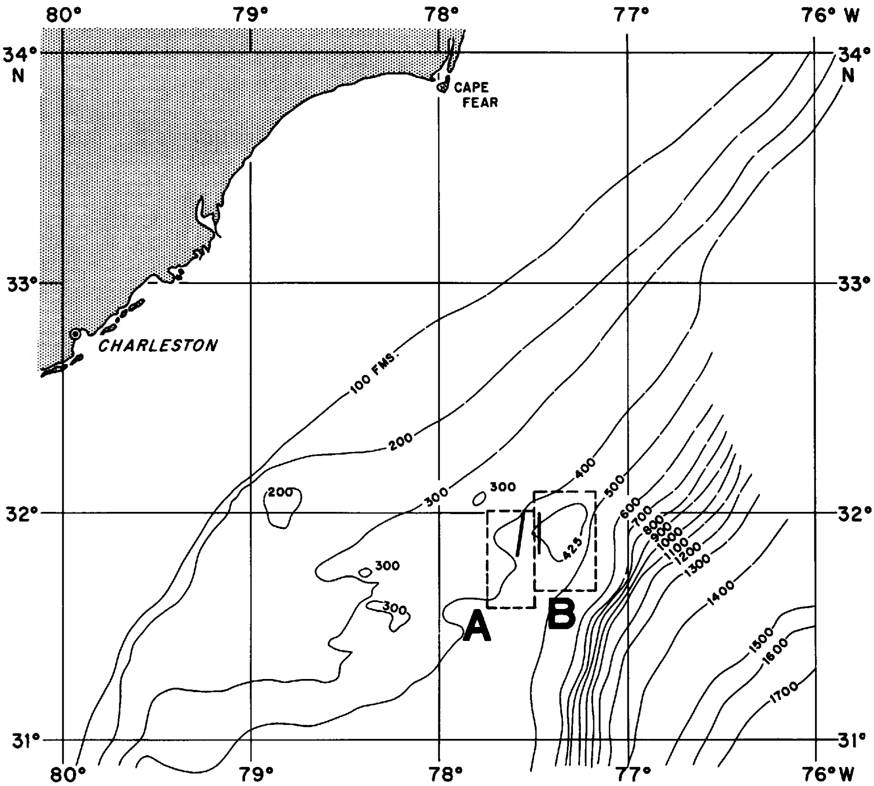

FIG. 1. Area of coral bank development on the Blake Plateau described in this paper. The two dark lines within the boxes delimit the western and eastern escarpments, respectively. The area enclosed in box A is the north-south trending escarpment and is further shown in figure 2. Area B encloses the greatest development of coral banks and is represented in three dimensions in figure 3. Contours are in 100-fathom intervals.

such a structure being that of M. Sars in 1865. Even so some zoologists and geologists perennially express surprise not only that corals exist in deep cold waters, but that in certain instances they create appreciable deposits of calcium carbonate, in the form of accumulations of their skeletal remains. The importance of these deep-water coral growths to the biologist lies in the fact that in many respects they are ecologically analogous to the coral reefs formed in tropical shallow waters; as a biological community, the reef structures, through their texture, form a variety of niches with differing micro-environments, affording habitats for numerous sessile benthos. These same attributes also result in their

being a locus of many of the vagrant animals that find refuge in the reef structure.

Deep-water corals, particularly those found in these deep-water accumulations, are usually found as scattered colonies or groups of colonies. On the deep-water "reef," a disproportionate abundance of coral is found, but perhaps more important is the sudden increase in diversity and numbers of individuals of almost all other groups. The deep-water "reefs" may therefore be a locus of high-density marine populations, a site of more than usual physiologic activity.

To the geologist, deep, cold-water "reefs" are of considerable importance in the interpretation of similar structures occurring in the geological past. The magnitude of this problem has already been emphasized by Teichert (1958) who encouraged "reappraisal of evidence and conclusions" of fossil reefs and bioherms, for, in some instances, these structures have been taken to indicate tropical shallow-water conditions for the formation of the sediments enclosing the reef and the reef itself.

Previous studies of deep-water coral structures were greatly hampered by a lack of tools with which to measure and probe them, for they are beyond the depth that permitted direct observation. Within the last decade the development of geophysical techniques, precision echo sounders, and deep-water photographic instruments has made possible the more intimate observation of these structures and permits interpretations of the structures which go beyond those of previous studies.

It should be emphasized that the present report is only a preliminary one, although this modern equipment has made possible the greater detail with which the physical aspects of the structures described in this study are treated. Much more intensive biological collecting is required before comparisons between these structures and those of the eastern Atlantic can be made. Further photography and collecting are required before the extent and distribution of coral growth on the structures can be determined. Finally, the position of the coral banks geographically will require regional study to ascertain whether they are fortuitously situated or whether there is environmental and geological control over their occurrence.

Terminology and Definitions

Because many of the descriptive terms that must be used in a discussion of coral structures have been given a variety of connotations in the literature, it is of the utmost importance that they be carefully defined. For example, the term "reef" has been so broadly applied in biological,

geological, and physiological literature that it is almost impossible to define except in the most general terms. We believe that the term "reef" has certain generalized connotations which are applicable to the structures described in this study; they are treated below.

Teichert (1958) and others, in avoiding the application of the term "reef" to deep- or cold-water coral structures have employed the word "bank." Teichert (1958, p. 1066) states, "because of the divergent use the term reef is receiving in American literature and because these coral formations in Norwegian waters exist far below effective wave base, they are here referred to as 'coral banks.' " Although this argument essentially evades the issue of the actual nature of the deep-water structures, it has merit in that too little is known of their structure, genesis, and biological composition for one to become fully engaged in the question of terminology. It should also be noted that the term "bank" is applicable to the structures described by Le Danois (1948) that occur along the margin of the continental shelf and upper slope of the eastern Atlantic.

As used in this study the terms "colony," "thicket," and "bank" form an isomorphous series, the distinction between them being rather arbitrary. The ahermatypic corals responsible for the deep-water bank are colonial forms with individual colonies attaining appreciable size, up to diameters measured in tens of feet. These arborescent structures are formed by asexually budded polyps which grow upward and outward from a single attachment or base. In the absence of physical wave attack, or biological weakening or destruction, presumably the only limitations in size of the colonies would be the strength of the skeletal material, aragonite. In the areas of distribution of the larger, deep-water, branching corals, such as *Lophelia*, the usual occurrence is as isolated colonies, often separated from one another by considerable expanses of non-coraliferous bottom. These then are occurrences of colonies, each, in certain respects, acting as a miniature bank.

Aggregations of contemporary colonies may form thickets, but unless these thickets have continuity in time, it is doubtful whether they are or would form banks, for the assemblage of the full fauna of the deep-water banks is presumably dependent on the accumulation of sediment, coral debris, and general modification of local environment that occur through time. There is no doubt but that some little modification of the environment is accomplished by a thicket, even if only in the sense of providing "cover" in the sense of its terrestrial equivalent.

The lateral juxtaposition of thickets results in the formation of banks. These are particularly noted along the edge of the continental shelf of Europe in the accumulation of coral known as the "corallian facies." In

this zone, Le Danois (1948) describes "massifs" formed by the corals *Lophelia* and *Madrepora* which occur on the continental slope from Porcupine Bank, off Ireland, to Spain, in depths of 200 to 2000 meters.

History of the Investigation

Evidence for the existence of coral banks on the Blake Plateau has been accumulating at Woods Hole Oceanographic Institution since 1956, in the form of echo soundings made on cruises under the direction of J. B. Hersey. These show the existence of many features with a relief of 10 to 40 fathoms. In August, 1957, during U.S.C.G.C. "Yamacraw" Cruise 3, an echo-sounding survey was conducted in an area where these features appeared to be most concentrated. To portray the survey, models were built of this area (figs. 2 and 3). Here two facing escarpments, both trending about north-south, bound a depression of irregular relief. The escarpments are shown in plan on figure 1; their relief is about 50 and 100 fathoms, east and west, repectively. On R.V. "Atlantis" Cruise 251, in the fall of 1959, and during R.V. "Bear" Cruise 250, in July, 1960, these areas were visited again.

In the spring of 1961, an intensive program of bottom photography, dredging, and seismic reflection profiling was carried out in these areas (T. R. Stetson, 1961), which provided sufficient data to confirm the existence of coral banks. "Atlantis" Cruise 266 made 52 dredge hauls, 25 camera lowerings, 47 seismic profiles, and 12 bottom-current measurement stations.

Previous Studies of Deep-Water Banks

The literature pertaining to deep-water coral structures is large, but it seems unnecessary to review it in detail, since two relatively modern summaries exist, both containing excellent bibliographies. Instead, a general discussion of the more important contributions is given in order to establish the extent and direction of previous study. For surveys of deep-water coral structures, attention is directed to Dons (1944) and Teichert (1958). Vaughan and Wells (1943) and Wells (1957) have excellent bibliographies and summaries of coral ecology and distribution.

Apparently the first record of deep-water coral banks was that made by Sars in 1865. Since that time, the occurrence of large coral masses in fiords and along the coast of Norway and continental Europe has attracted considerable attention, principally in relation to the fishing industry. As these banks are often excellent fishing grounds, but are also

great hazards for fish nets, their areal extent and distribution are of considerable importance, and several attempts at mapping the distribution of these deep-water coral banks have been made, the most notable of which are those of Le Danois (1921) and Joubin (1922).

Since the review of deep- and cold-water banks by Teichert (1958), little additional literature has appeared. Moore and Bullis (1960) recorded the first deep-water coral structure from the western Atlantic, east of the Mississippi Delta in depths of 230 to 280 fathoms. This record of the accumulation of considerable colonial coral, together with sounding data indicating topographic relief, is an isolated occurrence, but the authors suggested that more of these structures would be found in the western Atlantic.

Since the preparation of the present paper, Allen and Wells (1962) have published an important account of Holocene banks in the Niger Delta region which, in addition to data on the corals and their ecology, contains extensive discussions of the topographic expression of these banks.

In the past, several bathymetric studies of the Gulf of Mexico (H. C. Stetson, 1953; Ludwick and Walton, 1957) have indicated the presence of prominences on or below the shelf edge. In some instances it has been demonstrated that hermatypic corals are living on the upper surfaces, and, although little is known of the interiors of these structures, they are attributed to construction by tropical reef corals.

Methods of Study

The data presented here result from "Atlantis" Cruise 266, with the exception of the "Yamacraw" echo-sounding survey and portions of other cruise tracks where echo soundings were made. The echo-sounding system used in all cases employed various models of the Precision Graphic Recorder (PGR) and are based on a sound velocity of 4800 feet per second and are uncorrected (Knott and Hersey, 1956).

The three types of bottom sampling gear used were: the van Veen grab; a pipe dredge 12 inches in diameter and about 5 feet in length; and a rock dredge with chain bag. The grab sampler did not give very satisfactory results, apparently because of the hardness of the substrate, and the currents encountered caused the sampler to carry off from the ship. The collecting operation was monitored by a pinger the signals of which were recorded on the PGR. In several instances, the crash of the closing jaws was also recorded. The end of the pipe dredge opposite the mouth was covered by a screen, which in turn was covered by a piece

of canvas to retain the fine fraction of the sample. The rock dredge was modified by the addition of a canvas bag which was lashed into the bottom half of the chain bag and also proved effective in retaining fine sediments.

One principal problem in dredging is that the investigator does not know where his dredge is in relation to the bottom topography displayed by the echo sounder. It is therefore possible to say only generally where a sample came from in relation to the coral structure. In the coral bank province, topography favored collection in a number of ways. The bank to be sampled was always the feature of greatest relief, so that by the paying out of only enough cable to reach it, and not the general bottom level, it was reasonably certain that the sample came from the bank alone. In other instances, the position of a bank was established, and the vessel took such a position that the drift carried it back over the feature while the dredge was on the bottom. Dredges were usually on the bottom for about 15 minutes.

Bottom photographs were taken with Edgerton cameras. A few of the lowerings were done with an *f*.11 stereo pair, but the stereoscopic effect appeared to be less important in this instance than a greater depth of field. Accordingly, one *f*.11 camera (focused at 10 feet in air) and one *f*.4.5 camera (focused at 15 feet in air) were combined and produced clear pictures, from one roll or the other, from 2½ feet to 20 feet off the bottom. The 100-foot rolls of film permit up to 500 frames to be taken, but in actual practice, only 200 to 300 exposures are usable, as the remainder are out of focus.

The Edgerton camera frame has a pinger attached so that the camera-to-bottom distance can be monitored by the PGR (Edgerton and Cousteau, 1959). The camera is lowered and left near the bottom for about two hours, while its depth is continually adjusted so that the bottom will remain in focus. A long track is covered by the camera, a consequence of the duration of the lowering and the ship's drift. Most of the present work was done within the Gulf Stream, and on some stations drift was as great as 5 miles.

As it is possible to maintain a continuous bottom trace (sometimes only spot checks) on the PGR at the same time as a camera station is in progress, some idea of the bottom traversed during a camera station is obtained but cannot be taken as the actual track of the camera. Because of kiting, the camera may be outside the echo-sounder cone of energy and may be looking at different bottom than that traversed by the ship. On several of the camera stations, however, enough of the surrounding area was known by echo soundings to correlate the coral banks with the

features on the PGR record.

Although the precise identification of the animals represented in bottom photographs is often impossible and usually tentative, this type of biological reconnaissance alone is unsatisfactory. Bottom photographs, coupled with dredge collections, enable sufficiently numerous identifications of the larger organisms to be made so that photographs become very important tools for the estimation of the density of life and its distribution. This becomes increasingly important as the size of the sessile benthos increases and in relation to the nektonic forms of life which are not taken in the types of gear customarily used. Meaningful quantitative estimates of the relative abundance of dead and live coral could not be made without photographs, nor could the distribution of live coral be appreciated.

The seismic methods are discussed below, where the interpretation of the data is taken up. The current measurements are not sufficiently numerous to permit detailed interpretation but suggest the importance of currents as an environmental factor.

Navigational control was provided entirely by Loran A. Owing to shore-station drift, atmospheric conditions, ship's receiver, and differences among observers, considerable error may be introduced into loran navigation, but with care in both the taking and plotting of fixes, accuracies within plus or minus one-half of a mile can be obtained in this area.

Sea work was conducted by Stetson and Pratt, particularly during "Atlantis" Cruise 266. They are responsible for the physical aspects of this study, while Squires made the biological interpretations.

Acknowledgments

The United States Navy has generously supported past cruises by the "Bear" and "Yamacraw" and "Atlantis" Cruise 266 under contract Nonr-1367(00). Echo soundings from these cruises have been used in making the contour chart and models used in the present paper. We gratefully acknowledge the assistance of the officers and crew of the various expeditions and especially Captain A. D. Colburn of "Atlantis" on Cruise 266. Mr. Carl Ketchum assisted in the preparation of the topographic models in 1959. Mr. Thomas R. McGetchin made the sediment analyses. The drafting was done by Mr. Charles C. Innis. The field work could not have been undertaken without the inspiration and guidance of Dr. J. B. Hersey. His comments and observations during the preparation of the manuscript are greatly appreciated.

PHYSICAL DESCRIPTION OF THE CORAL BANKS AND SURROUNDING AREAS

Regional Setting

The Blake Plateau is an extensive, nearly flat area that lies in the bend in the coastline of the southeastern United States between Florida and North and South Carolina. From the coast to approximately 60 miles off the shore line, the continental shelf gently slopes to the east at a gradient of about 1:40 to depths of 300 to 400 fathoms. The Blake Plateau itself is much more horizontal, having, in general, gradients of 1:1000. The seaward slope of the Blake Plateau, however, is a precipitous escarpment which drops off to depths of more than 2000 fathoms (Heezen, Tharp, and Ewing, 1959). The Blake Plateau is postulated to represent a continuation of the Atlantic coastal plain, but it interrupts the usual slope profile such as that found north of Cape Hatteras. Both Cretaceous and Tertiary sediments outcropping on the Atlantic coastal plain have been postulated to continue eastward under the Blake Plateau (Le Grand, 1961; Hersey, Bunce, Wyrick, and Dietz, 1959; Drake, Ewing, and Sutton, 1959).

Geophysical investigations that have been conducted at sea between Cape Hatteras and Cape Canaveral have provided evidence that the geology of the Blake Plateau, at least locally, is very complex (Hersey, Bunce, Wyrick, and Dietz, 1959). Seismic evidence indicates that faulting has accompanied the relative subsidence of a ridge which is a seaward extension of the Cape Fear Arch. There is also evidence that complex structures have topographic expression as linear ridges and depressions on the northeast portion of the Plateau. It is on the flanks of the seaward extension of structures associated with the broad Cape Fear Arch that the coral banks are developed.

The area of coral banks (areas A and B of fig. 1) is located at the northern end of the Blake Plateau where it narrows between the continental terrace to the west and the deep ocean basin to the east. The area, bounded by latitudes 31° 30′ N. to 32° 10′ N. and longitudes 77° 20′ W. to 77° 45′ W., comprises about 1800 square miles, and more than 200 banks are recognized in sounding traces. However, the banks are not necessarily confined to this area. The shallowest occurrences located in the course of "Atlantis" Cruise 266 are in about 280 fathoms of water much nearer the continental shelf, but dredging and photography were not attempted, so their nature can only be assumed to be the same as those more intensely studied. The deepest banks found are in about

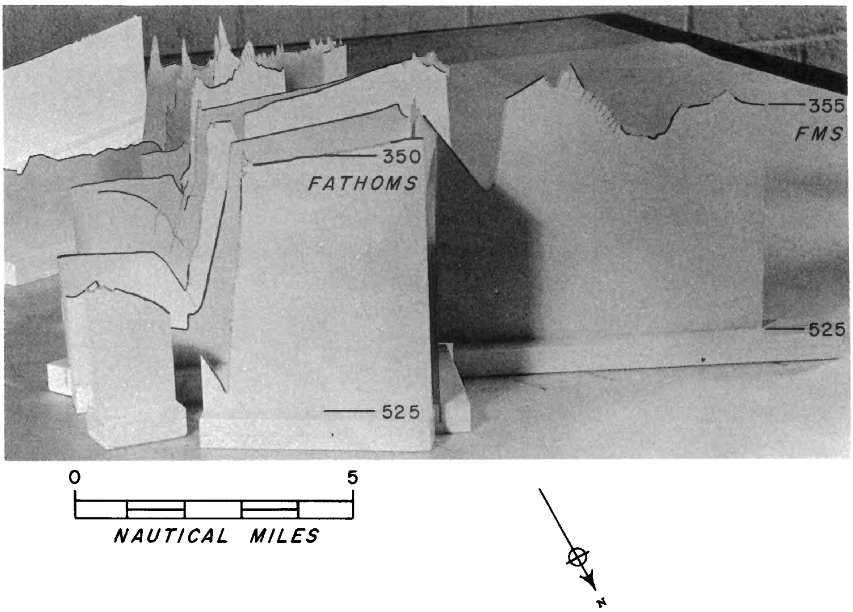

FIG. 2. Model of the western north-south trending escarpment as seen from the north. The area represented is approximately that of area A in figure 1. Note the number of coral banks, appearing as sharply pointed peaks, on the higher wall of the escarpment. Vertical exaggeration approximately 27.

475 fathoms of depth where the Blake Plateau merges into the outer escarpment.

The banks are well developed on a north-south trending line on the crest of an escarpment, as shown by figure 2. Smaller banks are found both to the east and west of the escarpment.

ECHO SOUNDINGS

Echograms across the coral banks consist of three principal types of echo sequence, illustrated in figure 4: (1) a dark recording of many successive similar echoes the travel times of which change gradually with time; (2) striking sequences of crescent form commonly appearing less intense (i.e., less dark) than 1 and 3; and (3) sequences in which echo trains from two successive pings are not simply related (resulting in diffuse or fuzzy recordings). In many instances, the outline of these sequences (type 3) may be crescentic. Recordings of type 1 are commonly interpreted as representing a continuous flat or gently sloping surface which

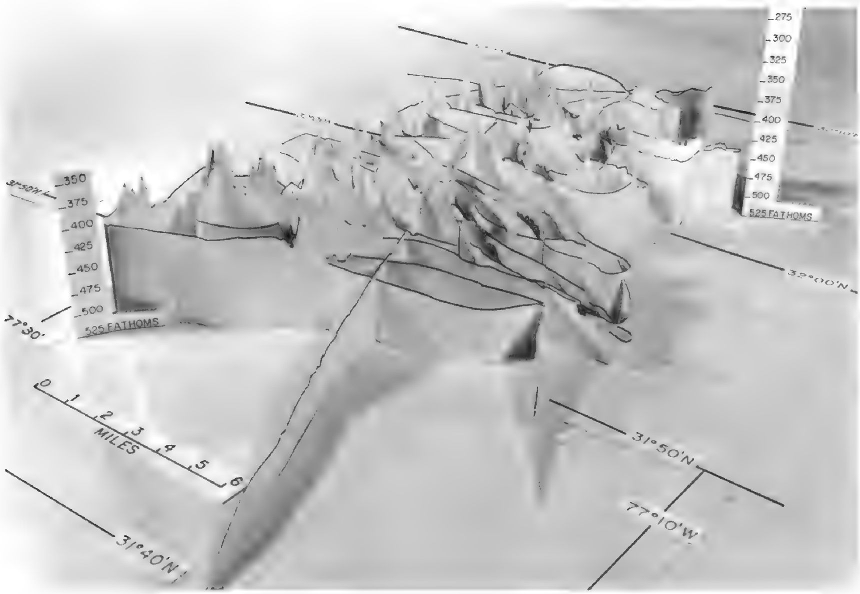

FIG. 3. Model of the area containing the greatest number of coral banks as seen from the southeast. The area represented is approximately that of area B in figure 1. The coral banks appear as sharply pointed peaks. Notice the trend toward north-south linearity in their arrangement. Vertical exaggeration approximately 20.

may have finely textured relief. Photographs of "flat" parts of the Blake Plateau corroborate such an interpretation of the echo soundings there. The crescent form of echo sequence (type 2), in which neighboring echoes are similar, is interpreted as coming from a comparatively small reflector which is detected by the echo sounder as the latter approaches and departs. Thus the top of the crescent is the closest approach of the echo sounder, though it does not guarantee that the instrument has passed directly over the object. (A point reflector would also give a hyperbolic trace.) Type 3 is thought to be composed of many weak echoes from small objects or small reflecting surfaces at differing distances. The position of the echo sounder is thought to change rapidly enough to change radically the expected echo train in each successive sounding.

Initially the problem was to identify the small reflectors that caused the crescentic and diffuse echo types from echograms of the bank area. We know from the present collections and photographs that they are, in part at least, coral banks. Qualitatively the collections and the character of the echograms are concordant. The diffuse echoes may have come from

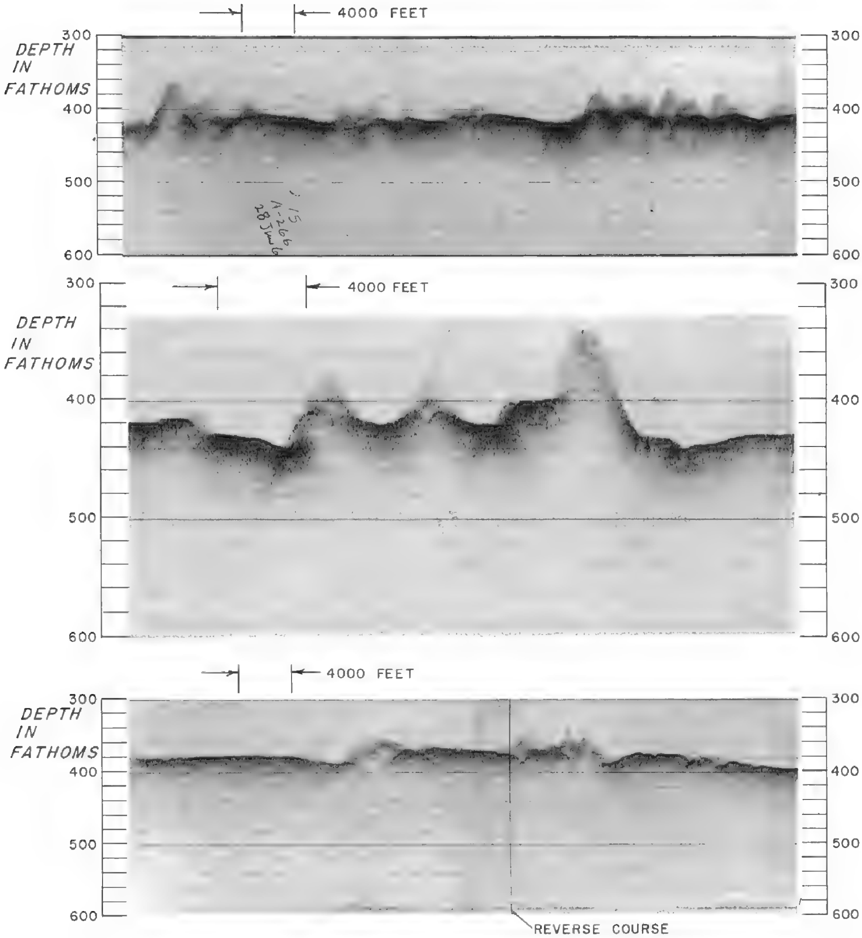

FIG. 4. Representative echo-sounding profiles in the area of the coral banks. *Top:* A number of banks along a sounding track made June 28, 1961, at approximately 31° 52′ N., 77° 32′ W. *Middle:* Several large coral banks; sounding made July 1, 1961, at 32° 03′ N., 77° 32′ W. *Bottom:* Coral banks aligned along the north-south escarpment; note reversal of course and change in horizontal scale. Sounding made July 3, 1961, at 31° 44′ N., 77° 34′ W.

branching coral. They may have come also from jagged rock surfaces, or from coral fragments embedded in soft sediment (Elmendorf and Heezen, 1957).

Some idea of the size of the banks may be gained from the echo-sounding profiles (fig. 4). A bank was selected having strong horizontal reflectors on each side which were discontinuous beneath the crescent of

the bank. A suitable example would be the bank under the words "4000 feet" in figure 4, lower echogram. This bank, at this crossing, would be somewhat less than 4000 feet wide. Preliminary analysis of these echo soundings and others not shown tend to support the hypothesis that as the banks grow upward they develop a steeper side slope and they approach a pinnacle form, composed of a steep-sided area of active coral growth near the top and a flatter, lower, debris area at the base.

TABLE 1

PARTICLE SIZE DISTRIBUTION OF REPRESENTATIVE SEDIMENT COLLECTIONS

(Proportions of various particle sizes, measured in millimeters, are stated as percentages of the entire sample by weight.)

	<2.0	2.0–1.0	1.0–0.5	0.5–0.25	0.25–0.125	>0.125
Top of coral bank						
Sample 25	65.0	10.2	11.2	11.9	1.2	0.5
Flank of coral bank						
Sample 4	32.0	8.5	6.0	3.3	8.4	41.8
Sample 11	24.1	4.8	6.6	26.7	11.0	26.8
Interbank area						
Sample 5	14.7	7.2	9.3	26.9	8.9	33.0
Inner shelf area						
Sample 36	0.5	5.6	32.8	48.6	10.7	1.8
Pelagic deposits						
Sample 49	6.9	2.5	18.8	70.2	1.3	0.3
Outer shelf area						
Sample 12	0.1	0.1	0.8	2.2	7.2	89.6

SEDIMENTARY ENVIRONMENT

A few sediment samples have been obtained from the outer escarpment (Ericson, Ewing, and Heezen, 1961), and a number of studies have been made of the shallow shelf sediments (H. C. Stetson, 1939; Moore and Gorsline, 1959), but samples recorded in the literature from the Plateau are rare.

Samples taken on "Atlantis" Cruise 266 indicate a distribution of sediment types corresponding roughly to bathymetric divisions: (1) terrigenous sediments, including coarse sand, silt, and silty-clay deposited on the continental shelf; (2) pelagic sediments deposited on the Blake Plateau; and (3) a mixture of pelagic and fine terrigenous silts, and muds, deposited on the outer slope of the Blake Plateau. The coral banks are in the area of pelagic sediments.

Particle size and coarse-fraction composition analyses of nine repre-

TABLE 2

COMPOSITION OF REPRESENTATIVE SEDIMENT COLLECTIONS

(Source of coarse fraction particles is stated as a percentage of the entire sample.)

	Coral	Foraminifera	Pteropod	Pelecypod	Gastropod	Quartz-Feldspar	Others
Top of coral bank							
Sample 25	76.5	16.0	5.3	—	0.5	—	1.2
Flank of coral bank							
Sample 4	39.4	12.5	4.5	—	0.5	—	1.3
Sample 11	28.4	39.4	3.8	0.8	0.4	—	0.3
Interbank area							
Sample 5	23.9	36.8	4.9	—	0.4	—	1.0
Inner shelf area							
Sample 36	0.7	0.7	—	5.1	0.1	89.6	2.1
Pelagic deposits							
Sample 49	6.7	85.6	6.1	—	0.6	—	0.8
Outer shelf area							
Sample 12	—	6.4	3.2	0.2	—	—	0.5

sentative samples from a total of 52 that were analyzed are given in table 1.

"Normal" shelf deposits (sample 36) are generally high in clastic non-carbonate materials and contain only relatively small amounts of biologically derived clastic particles. Particularly notable are the relatively small amounts of Foraminifera and pteropod skeletal material included in the sediment, as well as the small quantities of coral debris. The smaller proportion of pelagic biological material is largely the result of the masking effect of the deposition of terrigenous sediments on the continental shelf and not of lowered productivity. Sediments derived from the coastal plain of the United States are moved along the coast by long-shore currents and coastal currents and deposited on the shelf. The sedimentary particles fine enough to be transported out to the Blake Plateau are apparently swept northward off the Plateau by the Gulf Stream. Measurements made on the Blake Plateau of the bottom currents indicate sufficient competency to transport even sand-size sediment. These finer particles are ultimately deposited in deeper water at the northern end of the Plateau, such as the area from which sample 12 was taken. This sample, again relatively low in pelagic biological constituents, is rich in fine clastic particles.

Pelagic deposits, characteristic of the area in which the coral banks are found, are represented by sample 49 (see also fig. 15). These sediments are basically a foraminiferal ooze, with varying amounts of pteropod remains. In proximity to a coral bank, the percentage of coral debris increases sharply. This is an unusual feature restricted to this particular region, for corals are relatively rare on pelagic oozes. The pelagic sediments are, of course, the result of biological productivity in the overlying waters, but the quantity and purity of the ooze in the region of the banks seem to be largely the result of current sorting and the transportation of fine terrigenous sediment from the region by the Gulf Stream.

The bottom sediment between coral banks, as exemplified by sample 5, is basically foraminiferal ooze, with quantities of coral debris and other finer materials added. As shown in the size analysis data (table 1), there is an increase in both the larger and smaller size fractions, that in the smaller fraction being the most striking. The coarse fraction is composed almost entirely of coral debris, but the finer clay-sized sediment is bluish calcareous mud containing only a small residue of siliceous spicules, fine silt, and phosphatic materials.

An individual coral bank may be separated into two primary sedimentary divisions, the uppermost area of living coral, and the flanks which consist largely of coral debris accumulation, with little living coral repre-

sented (figs. 11–13). The first area is represented by sample 25, the latter area by samples 4 and 11. In composition these areas are largely differentiated by the size of constituent materials, the summits of the banks, as would be expected, having the coarser grades of sediment, the bulk of which consists of large fragments of coral. Farther down the flanks of the coral banks, the coral material is relatively finer and the proportion of calcareous mud increases. It is the "dilution" of the coral debris by the calcareous mud that accounts for the decrease in proportion of coral debris represented on the flanks of the coral banks.

With the pipe dredge it was possible to dig into the coral banks and recover undisturbed masses of the bank sediment. On superficial examination these masses appear to be solid chunks of sticky bluish mud of some density, but on closer examination may be seen to be fine material held within a framework of coral debris and other organic materials. The mass is firm and difficult to break apart, but is readily dissociated when washed with a hose. The bulk of coral material remaining after the mud is washed out is nearly equal to the volume of the original sample.

Sample Descriptions

Sample 4: 31° 56′ N., 77° 26′ W., 420 fathoms. Pipe-dredge sample from the flanks or debris slopes of a coral bank. The fine constituent is a plastic, carbonate mud.

Sample 5: 31° 57′ N., 77° 25′ W., 430 fathoms. Representative of interbank area close to the flanks. Pipe-dredge sample.

Sample 11: 31° 48′ N., 77° 22′ W., 434 fathoms. Van Veen sample from a bank, but it is small and probably lacks a representative amount of coral.

Sample 12: 32° 01′ N., 76° 59′ W., 700 fathoms. Pipe-dredge sample from the smooth outer slope of the Blake Plateau and representative of a mixture of terrigenous and pelagic constituents.

Sample 25: 31° 48′ N., 77° 35′ W., 355 fathoms. A large pipe-dredge sample from the top of a reef on the north-south escarpment and representing the actively growing crest.

Sample 36: 32° 09′ N., 79° 17′ W., 25 fathoms. Pipe-dredge sample with predominance of well-sorted terrigenous sand from the inner shelf area.

Sample 49: 30° 54′ N., 78° 40′ W., 450 fathoms. Pipe-dredge sample from south of the bank area, representing the pure pelagic ooze of much of the Blake Plateau.

Rock Substrate

The history of rock dredging on the Blake Plateau began with the original cruises of the Coast Survey Steamer "Blake" when Agassiz collected manganese nodules and coral (Agassiz, 1888). No other rock collections were recorded until recent "Atlantis" and "Vema" seismic cruises (Hersey, Bunce, Wyrick, and Dietz, 1959), which again recovered manganese nodules and calcareous material in small quantities.

During "Atlantis" Cruise 266, 52 dredge hauls were made, of which 10 recovered consolidated foraminiferal ooze and 11 collected manganese nodules. No other type of rock was obtained, and there are strong indications that some of the hard, indurated, foraminiferal ooze (calcareous sandstone) constitutes bed rock in the area of the coral banks. The dredge samples and photographs of the bottom indicate that the indurated foraminiferal ooze and manganese slabs and nodules form a resistant layer over most of the Blake Plateau. These rocks, together with the sediment cover of rippled ooze, make sampling of the underlying strata difficult.

The best evidence as to the nature of the underlying rock formations and reef structure can be obtained by geophysical methods. Shallow subsurface layering is very apparent in continuous seismic profiles, and individual layers can be traced as flat-lying units for considerable distances. The units change thickness eastward toward the outer escarpment and pass into the continental slope to the west. The banks are superficial features essentially contemporaneous with unconsolidated sediment deposits.

The main bank deposit province is on a raised platform at the northern end of the Blake Plateau (fig. 1, area B). This raised platform is cut by a north-south-trending linear escarpment which has a maximum relief of about 50 fathoms and a linear extent of about 20 miles (fig. 3). This, as well as the escarpment shown in figure 2, has been interpreted as a fault structure, although the evidence is not conclusive. The flat-lying rock horizons of figure 2 are truncated by the escarpment, but some of the layers beneath this feature seem to follow through, as is illustrated by profile 19 in figure 5. Coral banks are also localized along the crest of the north-south-trending escarpment shown in figure 2. The cause of this alignment is not known, but may in part result from the presence of outcropping rock on the escarpment which afforded an initial substrate for coral growth.

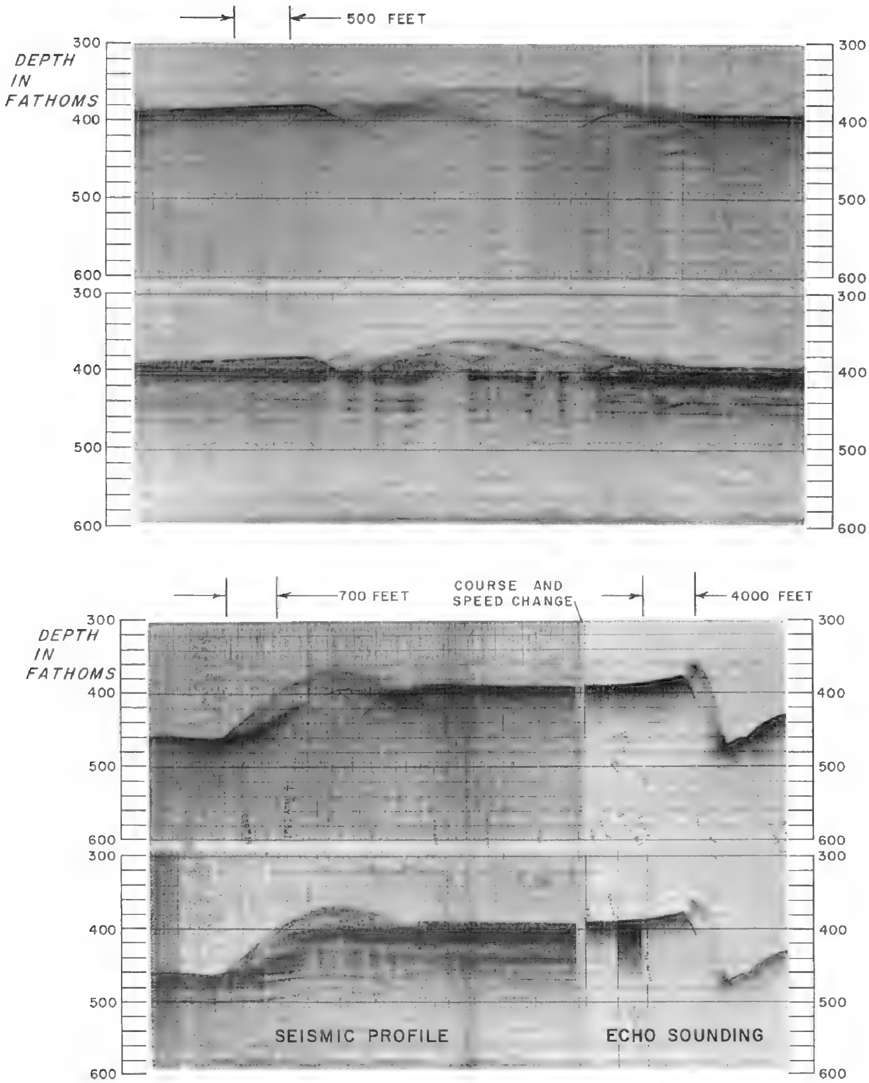

FIG. 5. Representative continuous seismic profiles. *Top:* Portion of profile 16, showing a well-developed bank on an otherwise flat bottom. Upper channel band: 2400–9600 cycles per second. Lower channel band: 67.5–225 cycles per second, July 3, 1961. *Bottom:* Comparison of continuous seismic profile 19 with an echo sounding over similar features. Difference in horizontal scales results from differences in ship's speed. CSP upper channel band: All above 1200 cycles per second. Lower channel band: 67.5–225 cycles per second. July 3–4, 1961; 31° 48′ N., 77° 34′ W.

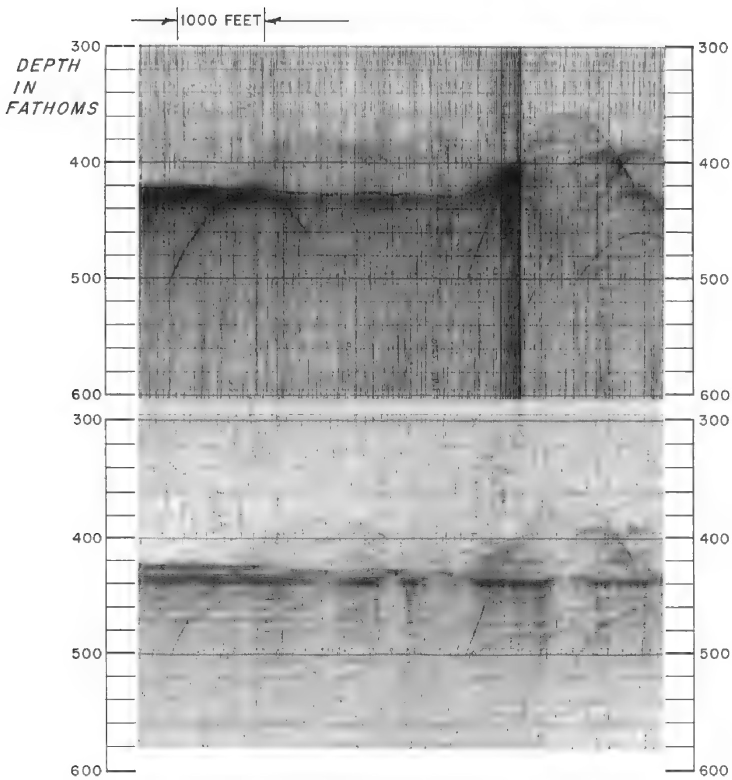

FIG. 6. Portion of continuous seismic profile 6, showing strong, sub-bottom, reflecting horizons underlying the coral bank structure. Upper channel band: 1200–4800 cycles per second. Lower channel band: 60–720 cycles per second. June 29, 1961; 31° 52′ N., 77° 19′ W.

SEISMIC PROFILES

The continuous seismic profiles reproduced in figures 5 and 6 were made with the Edgerton Sonar Thumper as a sound source (Hersey, Edgerton, Raymond, and Hayward, 1960). The receiver in all cases was a broad-band Clevite Corporation AX-58 hydrophone. The signal from the hydrophone was amplified and led to two passive filters. One of these was adjusted to pass a frequency band in the range of 1200 to 9600 cycles per second or higher. The other was adjusted to pass a frequency band around 60–720 cycles per second. The two signals were then fed to a dual-channel Precision Graphic Recorder and were displayed simultaneously on the record as half-wave rectified traces.

Interpretation of these recordings involves the comparison of the high-frequency channel trace with that of the low-frequency channel. Penetration of sub-bottom horizons appears on the low-frequency trace but may be confused with side echoes, which can be recognized and discounted because they appear on the high-frequency trace while sub-bottom echoes do not. The depth of sub-bottom penetration with any given source is dependent on bottom reflectivity, refraction, scattering,

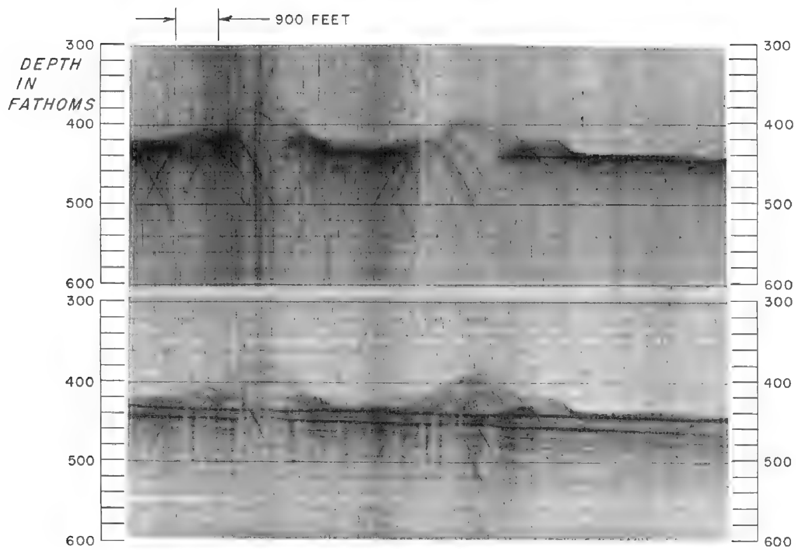

FIG. 7. Portion of continuous seismic profile 4, showing strong sub-bottom reflectors underlying the coral bank structure. Upper channel band: 105–600 cycles per second. Lower channel band: 1200–4800 cycles per second. June 28, 1961; 31° 52′ N., 77° 21′ W.

damping, and absorption. In the profiles represented here penetration does not exceed 100 fathoms. The significance of a fade-out of the strong horizontal reflectors on some of the profiles, notable profiles 4 and 6 (figs. 6 and 7, respectively) is not well enough known to be discussed at great length. These fade-outs are often observed to be coincidental with the peaks of individual banks. It may be that the overburden has absorbed or deflected the energy at the point where the overburden is greatest. The right side of the lower trace of profile 6 (fig. 6) is particularly illustrative of the instance in which a fade-out occurs coincidental with a bank. However, there are instances (profile 6, center, in fig. 6; and fig. 5) in which fade-outs are not coincidental with peaks, so some other

hypothesis must be sought. These fade-outs could be caused by an interruption in bedding by intrusive bodies. Where the strong underlying horizontal reflectors are interrupted they appear to be bent upward, which indicates an increase in sound velocity and may represent compaction of sediments around an intrusive body. Where there is not complete interruption, the horizontal layers appear to continue through, representing an attenuation of energy, perhaps owing to the taking of the profile at some point off the vertical axis of the igneous body. Such bodies, if their presence is confirmed, may very well have served as the platform on which the coral banks were initiated.

The profiles taken on "Atlantis" Cruise 266 clearly show a lack of stratification of the reef material, while the underlying formations are prominently layered. This picture of the banks is what might be expected from a coral framework with entrapped sediment. Profile 19 (fig. 5) shows well-developed banks on the western side of the north-south escarpment. It is evident from these profiles that a structural platform has been offered by the consolidated sediments now underlying the coral banks.

BIOLOGICAL NATURE OF THE CORAL BANKS

The Corals and Associated Fauna

The following remarks on the biological content of the Blake Plateau banks are very preliminary in nature. The identifications of organisms and the statements of the diversity of species are based largely on an examination of bottom photographs, although considerable quantities of biological material were collected during "Atlantis" Cruise 266. Of these collections, the living material, insofar as possible, was preserved in formalin, while the great mass of dead coral was placed in sacks and dry stored. The examination of the biological collections has been preliminary and has not resulted in detailed identifications below a major group, with the exception of the corals. Because of the type of biological collecting gear, that is, pipe and chain dredges, only a very speculative representation of the fauna has been collected. As they are the dominant organisms on the bank, only the corals are considered in any detail in the following discussion.

Two species of dendriform branching coral are responsible for the skeletal material composing the bulk of the reef: *Lophelia prolifera* and *Dendrophyllia profunda*. Because of their mode of growth, these two species, although grossly similar, can be readily distinguished in areal bottom

photographs (see Squires, 1959, for further discussion of the systematics of the coral species represented in this fauna). *Dendrophyllia profunda* appears to be the dominant species in terms of abundance in all areas of the bank, with the exception of the uppermost part, for at the tops *Lophelia prolifera* becomes more important, although *Dendrophyllia profunda* remains in about the same numbers. Therefore, although both species are distributed over the surface of the banks, there is a distinct and striking increase in the quantity of living coral toward the top of the bank, where sharp increases in both species, but particularly in *L. prolifera*, occur.

An examination of photographs (fig. 8) indicates that fragments of dead coralla of *Dendrophyllia profunda* are the most common constituent of the substrate, except near the upper portion of the bank where large fragments of *L. prolifera* become abundant. Other corals associated with *L. prolifera* and *D. profunda* are *Bathypsammia* spp. and *Caryophyllia clavus*. The evidence of distribution taken from the photographs (fig. 14) indicates that *Bathypsammia* is most common in the area adjacent to the base of the reefs. Because the position of the dredges on the bottom is not known relative to the topography over which the ship was moving, and because it is possible for the dredges to sample more than one community, establishment of biological entities is difficult, but there are apparently two discrete coral assemblages. The first, the true bank assemblage, is formed of *Lophelia* and *Dendrophyllia*, with accessory species including *Bathypsammia*, *Caryophyllia*, and *Balanophyllia*. The inter-reef, rock-bottom fauna is composed of *Bathypsammia*, *Caryophyllia*, and *Balanophyllia* exclusively, but in greater numbers of individuals than are present on the bank.

All the corals noted are ahermatypic types lacking zooxanthellae. Indeed, at the depth of the banks, autotrophic flora would be a surprising constituent. No plants and, in particular, no calcareous algae were recognized among the collections.

Among the other fauna of the banks are abundant Hydrozoa and Alcyonaria, most of which occur as current-oriented flabelliform colonies. Echinoids are common but are represented mainly by dead tests. Actinians in considerable variety are present in the collections and well represented in the photographs (fig. 11), particularly in areas of coral detritus. Ophiuroids are abundant, particularly in the detrital areas. Mollusca, particularly the larger forms, are most notable for their general rarity.

Corals as Bank-forming Organisms

Two facts become immediately apparent on examination of the dredge samples, particularly when large quantities of sediment were obtained:

FIG. 8. Coral growth near the top of a bank. *Dendrophyllia profunda* dominates. Living coral is white; dead debris appears black. Bottom edge of photograph is approximately 20 feet.

(1) only the colonial corals are significant as framework organisms and in the formation of sediment; and (2) *Dendrophyllia profunda* is significantly

FIG. 9. Growth of *Dendrophyllia profunda* showing large unbroken coralla in center and lower foreground. Bottom edge of photograph is approximately 12 feet.

more important as a sediment former than *Lophelia*, while the latter perhaps provides the better framework. In sample after sample it could be seen that dead fragmentary coralla of *Dendrophyllia* were smaller in size

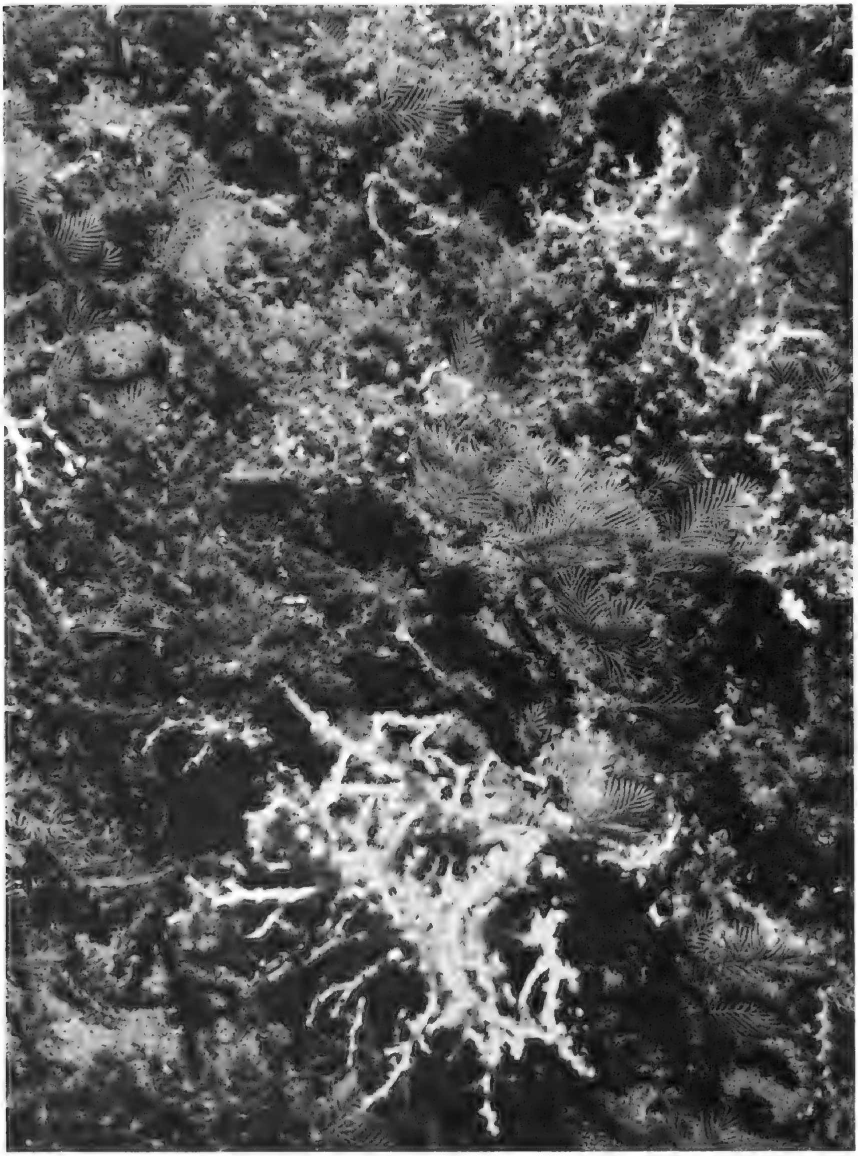

FIG. 10. Details of bank fauna with *Dendrophyllia profunda*, hydroids, and Alcyonaria. Bottom edge of photograph covers about 4 feet.

that those of *Lophelia*, and where sediment had been roughly sized by washing through screens, *Dendrophyllia* was the only significant contributor in the finer fractions. On the other hand, large fragments of dead coralla

FIG. 11. Various coelenterates on the debris slope of a coral bank. Bottom edge of photograph covers approximately 4 feet.

were almost always found to be *Lophelia*, particularly the more massive basal portions of the colony of this genus.

Contributing to this dichotomy of function of the coral skeletons in

FIG. 12. Living *Dendrophyllia profunda* and the debris slope. Note the abrupt change in size of the coral fragments and the position of the change in slope across the center of the photograph. Bottom edge of the photograph covers about 10 feet.

bank formation is the basic growth pattern of the two species. *Dendrophyllia profunda*, the sediment former, forms a corallum of porous aragonite, which, even in its older portions, is sponge-like in texture and relatively brittle. Further, *Dendrophyllia profunda* tends to grow in an arborescent fashion, an individual branch seldom touching another, and, where branches come in contact, there is no fusion. As a result, the structure of the colony is loose, open, and very fragile. *Lophelia prolifera*, the framework former, on the other hand, has a skeleton which is dense, composed of

FIG. 13. Debris slope composed largely of *Dendrophyllia profunda* fragments, but also containing some *Lophelia*. Small octopus in lower right. Bottom edge of photograph is 6 feet.

concentric layers of aragonite. The calice, occupied and then abandoned by the polyp, is frequently filled with secondary deposits, so that in some

Fig. 14. Rock outcropping between banks, with organic ooze and nodules in lower foreground. White spots are probably *Bathypsammia* or *Thecopsammia*, small cup corals. Bottom edge of photograph represents about 4 feet.

instances the corallum is a solid mass of calcium carbonate. The growth form of *Lophelia* is not so lax as that of *Dendrophyllia*, and the branches

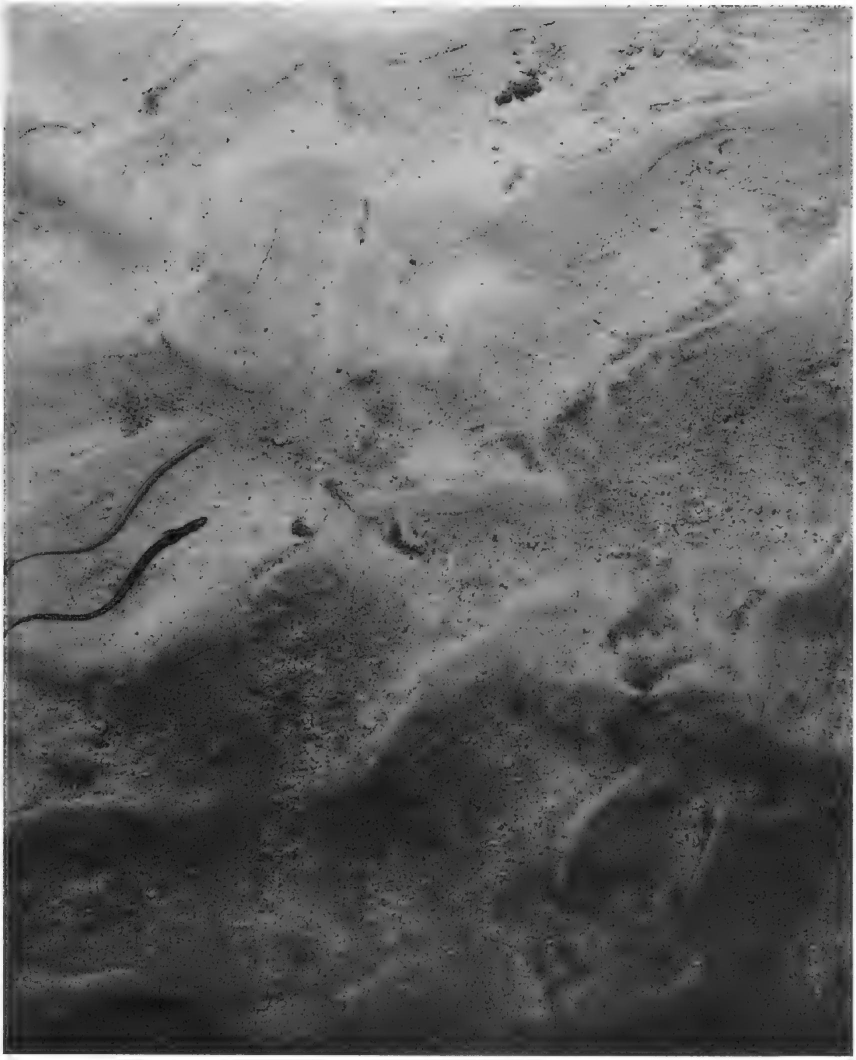

FIG. 15. Rippled sand and ooze characteristic of the bottom between coral banks. Notable absence of coral debris is the most characteristic feature. Bottom edge of photograph is approximately 3 feet.

are more steeply inclined, frequently coming in contact with one another. Where contact is made, aragonite is deposited by the coral, and the branches become solidly fused. *Lophelia* then is more strongly formed to withstand mechanical breakdown and occurs in larger, rather than smaller, fragments.

What factors are responsible for the breakdown of dead coral skeletons? In the instance of tropical shallow-water reefs, the question is not difficult to answer, for there are a host of organisms which feed upon, live within, or shelter among the corals. The effects of the biological activity of these organisms on the coral, together with the physical shock of wave attack to which the shallow-water structure may be subjected, readily cause the fragmentation and disintegration of coral material. Among the more important organisms in biological disintegration of coral are the filamentous green algae which live just beneath the polyp of hermatypic colonial corals. Apparently these algae are destructive, removing carbonate from the skeletal material by solution. Boring sponges and mollusks contribute to the breakdown of coral either through complete disruption or by weakening structures so that wave impact more readily fractures them. Certain types of fish are known to chew on live and dead coral and in some areas constitute an important cause of destruction of coral skeletal materials. Most important of all destructive influences, however, is the physical impact of the waves on the reef.

All these factors are apparently non-operative in the instance of the deep-water structures. As the coral banks are located below the photic zone, algae are not present. Specimens examined show little sign of the destructive biological activity characteristic of the shallow waters: molluscan and sponge borings are rare to absent. We have seen no evidence of fish chewing on these deep-water corals. The boring annelid *Eunicia* is one of the few common deep-water animals that are destructive to coral skeletons. The depth of the deep-water banks, at least those under consideration here, is such that wave activity is not present, and current action is too weak to be a destructive factor. The influence of fish on the fragile coral structures is not known, but presumably they could physically break a colony by swimming into it, either during evasive action or while seeking shelter.

Productivity of Coral Banks

An examination of the photographs taken on the flanks of the coral banks reveals a startlingly high proportion of dead coral material lying on the surface. This unusual abundance of fragments of dead coralla, ranging from fractions of an inch to pieces of branches 6 or 7 inches long, is the result of several contributing circumstances. There is no evidence of the solution of skeletal materials. There is, apparently, a paucity of life capable of grinding up the coral debris which accumulates from the breakage of a single colony (the quantity of debris to be obtained from a

single colony can be large). Undoubtedly many of the echinoderms, particularly ophiuroids, perform this function, but only on the smallest particle sizes. As a result, the breakdown of the larger particles (1 to 6 inches or more) is either absent or very slow—a fact recognized by the very high proportion of large fragments included in buried coral material. The apparent abundance of dead coral material on the reef flanks is also brought about by the slow rate of sedimentation. Fine mud and ooze being transported along the sea bottom accumulates on the coral bank largely because of the entrapping fine meshwork of coral fragments which causes a decrease in transporting current velocities. Apparently until this meshwork has reached a certain critical threshold of depth, density, and porosity, permanent accumulation of sediment will not occur. In other words, a relatively thick cover of coral debris and organic life is required before sediment, in the form of fine mud and pelagic ooze, will accumulate. This then is a built-in mechanism for retaining a thick cover of dead coral material on the surface of the bank.

Little is known of the rate of growth of these deep-water corals. Duncan (1877) and Pratje (1924) obtained growth rates of 6.8 and 7.5 mm. per year for *Lophelia prolifera*, based on cable records. These, however, can be taken only as minimum rates, and growth rates could be appreciably higher. The productivity of the coral bank is therefore extremely difficult to judge. Carbonate material is being added, at an unknown rate, and is apparently not being broken down rapidly. The total growth rate of the bank cannot be determined.

Environment of the Coral Banks

Too little is known of the physical setting of the coral banks described in this study for us to attempt a general description of the environment. Even the problem of the pattern, extent, and causes of the distribution of the coral banks is unknown. Physical data as known are presented in the following section, in which comparisons with other coral banks are made.

COMPARISONS WITH CORAL BANKS OF OTHER AREAS

Coral banks described from other areas differ greatly in the treatment they have received. Those of the Norwegian coast are well known biologically and environmentally, but lack physical description. The "massifs" off the European coast are described only generally, a few in some detail, but are best known from a biological standpoint. The record of a

coral bank from the Gulf of Mexico is based on a single crossing only. It is possible at the present time to make only general comparisons of coral banks, although some aspects of other banks are better known.

Table 3 presents some of the comparable data for the various coral bank areas. Many general similarities are immediately apparent, and the discrepancies result from the methods of study. It is apparent from these data that the coral bank environment, ecology, structure, and composition represent a uniform entity over the area of their occurrence, being similar in this respect to the shallow, tropical reef biotope.

The configuration of the coral banks in plan view is not known except very generally. Le Danois (1948) illustrates some of the "massifs" as being elongate parallel to the edge of the shelf, and in other instances as being more circular, but with the long axis at right angles to the shelf edge. These differences, indeed, the entire shape of the coral bank, are probably a function of local topography and currents, and little accord should be expected for widely separated areas. With the present methods of sounding, the mapping of the horizontal shape and extent of a single bank is difficult. In general, bank provinces appear to be linear in extent relative to water movements. All the banks described seem to be more or less rounded on the top, with the possible exception of some of the Norwegian structures, which have a flattened surface. This surface may result from wave planation of the fragile coral because of their shallower occurrence.

Where known to exist, coral banks seem to be present in considerable numbers. It is more than probable that some of the larger "massifs" of the European continental shelf are accumulations of banks. The pattern of coral banks may be associated with rock outcroppings or hard bottoms. Those on the Blake Plateau seem to follow bathymetric trends which are probably associated with the occurrence of rock, while the described banks from the Norwegian coast are built on rock or hard moraine bottoms (Dons, 1944). To the extent that the substrate affects the initiation of growth of the coral bank, substrate could be a prominent factor in the apparent structural control of the occurrence of the banks, as in the case of those on the Blake Plateau and the Gulf of Mexico.

The size of the individual bank is variable, as would be expected. The largest banks, on the Norwegian Shelf, are apparently over a mile in diameter, but whether these represent single banks or numbers of discrete banks is not known. Similarly, the height of the bank itself differs from place to place, the banks from the Blake Plateau having the greatest relief and being almost twice as high as those from other areas. One would expect the shallow Norwegian banks to have some limitation in upward growth, for the construction of a bank would not permit wave attack

TABLE 3

Comparison of Coral Banks from Several Areas of the North Atlantic

	Blake Plateau	Gulf of Mexico (Moore and Bullis, 1960)	Gulf of Mexico (Ludwick and Walton, 1957)	Norwegian Shelf (Dons, 1944; Teichert, 1958)	European Continental Shelf (Le Danois, 1948)
Diameter of bank	0.5 mi. maximum	More than 0.2 mi.	Less than 0.25 mi.	1.5 mi. maximum	Variable
Maximum known height of bank	480 feet	180 feet	30 feet	200 feet	200 feet
Shape of bank	Bank	Hillock	Pinnacle	Mounds	"Massifs"
Number of banks in group	200+	Several	Many	190	Unknown
Depth to base of bank	400 fathoms	280 fathoms	56–98 fathoms	30–150 fathoms	90–1400 fathoms
Substrate of bank	Carbonate rock?	Unknown	Sand	Rock or hard moraine	Unknown
Associated sediments	Calcareous mud and organic ooze	Mud	Silt and sand	Mud	Unknown
Temperature	7–10° C.	10.4° C.	18.0° C. maximum	6–8.4° C.	8–12° C.
Salinity	35‰	Not known	32‰–37‰	Not given	Not given
Framework corals	*Lophelia, Dendrophyllia*	*Lophelia*	Unknown	*Lophelia, Madrepora*	*Lophelia, Madrepora*
Associated corals	*Bathypsammia, Caryophyllia*	*Caryophyllia*	Several species	*Caryophyllia*	*Caryophyllia, Desmophyllum, Dendrophyllia, Solenosmilia*

without extensive damage.

The depth of occurrence is almost certainly directly related to temperature. Published descriptions show that most occurrences are below 100 fathoms, but variation beyond that is considerable. The shallowness of the structures described by Ludwick and Walton (1957) is unique and is further considered below. The deepest occurrences noted by Le Danois (1948) and Teichert (1958) are difficult to assess, for these records may be based on thickets and not banks. Temperature data indicate that the coral banks on the western Atlantic are possibly living under warmer conditions than those on the eastern side. Probably it is the cooler water temperatures encountered on the Norwegian Shelf which permit the shallower occurrences there. The optimum range of temperature appears to be between 8° and 10° C., the latter figure representing a maximum for coral bank development. Data presently available do not permit a guess as to the minimum temperature for coral bank formation, but the apparent general absence of coral banks from deeper or colder water suggests that there may be some such restriction.

All the coral banks seem to be developed in areas of, and to have configurations which are related to, current action. Norwegian banks are situated either at the edge of the continental shelf or at the entrance to fiords (Dons, 1944). The unusual situation of the banks described by Moore and Bullis (1960) suggests that some current action may be expected.

With the exception of the pinnacles described by Ludwick and Walton (1957), the coral banks of the Blake Plateau seem to be of the same biological character as those of other areas. The variations in the framework coral species are those to be expected as a result of geographic endemism. *Lophelia prolifera* is always the dominant constituent, while *Dendrophyllia profunda* and *Madrepora ramea*, homologous in the structure of the corallum, appear to be important contributors to a medium to fine grade of coral debris.

COMPARISONS WITH OTHER TYPES OF REEFS

The coral structures described by Ludwick and Walton (1957) are in many respects similar to the coral banks described here, but differ in many other important respects. They are smaller, differently shaped, and apparently are of different faunal composition. They occur in much shallower water than other banks and are present today in temperatures considerably higher than those tolerated by bank-forming corals elsewhere. The maximum temperature of 18° C. recorded for the area of the pinnacles (Lud-

wick and Walton, 1957, p. 2065) is also the minimum for active reef growth of tropical hermatypic corals.

Ludwick and Walton (1957) consider the pinnacles to represent reef developments which are now dead or dying. The reefs are postulated as having developed in depths of less than 25 fathoms under somewhat warmer conditions than those at present. Principal contributors to the reef are suggested as calcareous algae, Bryozoa, corals, carbonate-precipitating worms, mollusks, and Foraminifera. The absence of reef-building (hermatypic) corals in the rock is taken as evidence of unfavorable temperature and salinity conditions. The pinnacle form is attributed to dominant upward growth, as the reef-forming organisms attempted to maintain pace with rising sea level.

If the above interpretation is accepted, it would appear that these structures represent a form of marine carbonate deposit intermediate between present-day tropical reefs formed by hermatypic corals and the deeper water coral banks. Unfortunately, the fossil fauna of the pinnacles is not known.

Mounds described from the Gulf of Mexico by Stetson (1953) are not well known internally. Corals collected from the upper surface of these structures are known to be of the hermatypic type, and the structures do not appear to be related to coral banks, but rather may be interpreted as growths of hermatypic corals on fortuitous topographic highs. Deep-water coral banks can then have more than one type of genesis, so that each occurrence must be studied individually.

DISTRIBUTION OF CORAL BANKS

There is little doubt that coral banks will continue to be discovered, particularly as they are sought after. As an illustration of the problem, the coral banks on the Blake Plateau were known from echo-sounding surveys long before their true nature was recognized. Biological collections of the late 1800's yielded faunal evidence for the existence of large numbers of banks, but without the bathymetric control the banks were not recognized.

Moore and Bullis (1960) have suggested the occurrence of a coral bank north of Little Bahama Bank in 400 to 600 fathoms. The fauna recovered by the "Vema" at station V3-23, 27° 10′ N., 79° 34.9′ W. (Squires, 1959), is that expected of a coral bank, and the quantity taken is very similar to that of the more northern occurrences described here. "Albatross" and "Fish Hawk" collections in the United States National Museum indicate the occurrence of coral banks in dozens of localities on the Blake Plateau

between those described here and the Bahama Bank.

To date, the only occurrences of deep-water coral banks are in the North Atlantic. Without doubt, the same or similar structures will be found in deep water in the South Atlantic. The occurrence of large amounts of *Goniocorella dumosa* from New Zealand and the Japanese Continental Shelf, filling the ecological niche of the Atlantic bank-forming corals, suggests that coral banks may ultimately be described from the Pacific Ocean.

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